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# THE CHARACTERISTIC OF ACEL IN $ZnS:Er^{3+}$ THIN FILMS GROWN BY ATOMIC LAYER EPITAXY METHOD(ALE)

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The characteristics of ACEL in $ZnS:Er^{3+}$ thin films grown by ALE method were reported for the first time. The cross-relaxation model between $Er^{3+}$ ions was set up. The cross-relaxation rate was calculated.

## 1. INTRODUCTION

The work of electroluminescence in $A^{II}$ $B^{VI}$ thin films doped with rare earth ions initiated in 1968 by Kahng[1]. Recently, H. Kobayashi et al[2], have reported ACEL characteristics of ZnS thin films doped with $TbF_3$, $SmF_3$ and $TmF_3$, respectively. They have studied the interaction between ions and given cross-relaxation model.

In this paper we are reporting the characteristics of ACEL in $ZnS:Er^{3+}$ thin films grown by ALE method[3] and discussing the cross-relaxation processes between $Er^{3+}$ ions. The results show that the cross-relaxation processes will occur between excited $Er^{3+}$ ions.

## 2. EXPERIMENTAL

The EL devices are glass-$SnO_2$-$Y_2O_3$-$ZnS:Er^{3+}$--$Y_2O_3$-Al sandwich structure. The $Y_2O_3$ insulator layer was fabricated by electro-beam evaporation $ZnS:Er^{3+}$ layer was grown by ALE method. The ALE is based on chemical reaction in the solid surface of a substrate to which the reactants are alternately transported as neutral molecular or atomic vapor pulses (or beams)[4]. The thicknesses of $Y_2O_3$ layer and $ZnS:Er^{3+}$ active layer were about 300nm and 400nm, respectively. The concentration of $Er^{3+}$ ions in ZnS thin films ranges from 0.05% to 12%(wt).

## 3. RESULTS AND DISCUSSION

Two typical samples with different $Er^{3+}$ concentration were investigated. The $Er^{3+}$ concentration in samples A and B are 12% and 0.9%(wt), respectively. The EL spectra of both samples at room temperature(RT) showed that the emission intensity of $^4F_{9/2}$-$^4I_{15/2}$ transition increased strongly with increasing of $Er^{3+}$ concentration. $I(^4F_{9/2}-^4I_{15/2}) > I(^2H_{11/2}-^4I_{15/2})$ for sample A and $I(^4F_{9/2}-^4I_{15/2}) < I(^2H_{11/2}-^4I_{15/2})$ for sample B, as shown in Fig. 1.

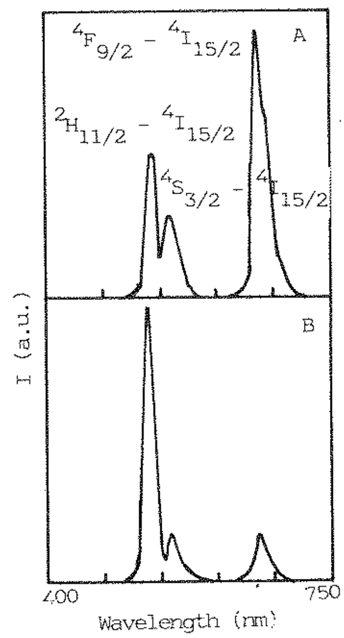


FIGURE 1
ACEL spectra of samples A and B at RT.

EL decay curves of sample A are different from that of sample B. The decay curves of

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$^2H_{11/2}$, $^4S_{3/2}$ and $^4F_{9/2}$ state in sample B are single exponential law. However, for sample A, there is a rising process in the EL decay of $^4F_{9/2}$ state and there are a fast and a slow component in the EL decay of $^2H_{11/2}$ and $^4S_{3/2}$ state. The EL decay curves of $^2H_{11/2}$ and $^4S_{3/2}$ state can approximately be expressed as

$$J=J_{10}*EXP(-t/t_1)+J_{20}*EXP(-t/t_2)$$

where $J_{10}$ and $J_{20}$ are initial brightnesses of slow and fast component, $t_1$ and $t_2$ are lifetimes of slow and fast component, respectively.

From above results, we presented an interpretation; the fast component of EL decay curves of $^2H_{11/2}$ and $^4S_{3/2}$ state results from relaxation from $^4S_{3/2}$ and $^2H_{11/2}$ state to $^4F_{9/2}$ state. These processes will enhance the emission intensity of $^4F_{9/2}$-$^4I_{15/2}$ transition. Nonradiative relaxation between electronic state of $Er^{3+}$ ions occurs usually by multi-phonon emission or by cross-relaxation. The former has been excepted[5]. By analysis of experimental results we may suppose the concrete cross-relaxation processes, as shown in Fig. 2.

The cross-relaxation rate of sample A calculated by the experimental data was about $1.4*10^5$ per second. This value was in agreement with that value($1.3*10^5$ per second) obtained by simulating decay curve.

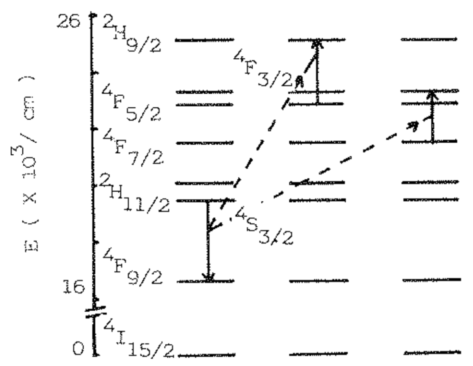


FIGURE 2
Possible cross-relaxation processes occurred between $Er^3$ ions.

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